

# Radial velocities of “slow movers” – call for observations

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## Abstract

This paper presents a list of suggested stars for radial velocity measurements. We explain here in brief the research project for which the radial velocity of the “slow movers” i.e. small proper motion stars are necessary. Basing on this study we prepared a list of 1100 stellar targets with very accurate positions, proper motions and trigonometric parallaxes but without radial velocity measurements. Distributions of stellar brightnesses and spectral types among these stars are presented as well as its “most wanted” subset. We announce the begin of the radial velocity measurements to be conducted in our observatory and offer some coordination for observations of targets that cannot be reached from our location.

Keywords: Stars: kinematics – Techniques: radial velocities

## 1 Introduction

During our research on the long-period comets origins we simulate the mechanisms of production of the observable comets directly from the Oort(1950) cometary cloud by means of stellar and galactic perturbations. A natural consequence of that study would be a search for stellar perturbers which passed near the Sun during the last several million years or will have such a chance in the future. Such passages can induce strong asymmetries in the observed population of the long-period comets, as it was showed by Dybczyński (2002a,b,c). Additionally, such passages should be taken into account when studying the past motion of observed long-period comets as it was demonstrated in **Dybczyński (2001)**.

In our first attempt to complete a list of potential stellar perturbers (Dybczyński & Kankiewicz 1999) we found, that the majority of stars with measured parallax (most of them are from the Hipparcos catalogue, ESA 1997) do not have their radial velocities measured what excludes them from further consideration. Similar conclusions were reported by García-Sánchez et al. (1999, 2001): they could attribute radial velocity values to less than 50% of the selected candidate stars. The lack of radial velocities in such cases is most often a consequence of the selection criteria used by observers. When searching for the promising candidate for radial velocity measurements they prefer stars which high proper motion suggests high space velocity. Thus “fast movers” (in the sense of

high proper motion) are highly favored. In our research we are interested in the stars moving almost directly towards (or outwards) the Sun what implies very small proper motion. We will call these stars “slow movers”.

## 2 Missing radial velocities

In our study on the stellar perturbations of the Oort cloud comets we decided to use the most precise subset of the Hipparcos catalogue (ESA 1997), the ARIHIP catalogue (Wielen et al. 2001b), containing the results of the Hipparcos mission re-reduced for better proper motion calculations with the aid of the precise ground based astrometric catalogues. ARIHIP is available on the Internet at <http://www.ari.uni-heidelberg.de/arihip/>. For our purpose we used the “long term” solutions included in ARIHIP because they seem to be the best available approximations of the long term motion of these stars. For a more detailed explanation see Wielen et al. (2001a).

Our procedure of selecting candidate stars is very similar to that used by García-Sánchez et al. (1999, 2001). For all stars with the reliable parallax in ARIHIP we calculated the miss-distance between a star and the Sun basing on the straight line motion model. As it was shown this simple model is quite sufficient as the first selection tool. In our first list of candidates (hereafter LC) we included all stars with the calculated miss-distance less than 5 pc assuming for all stars  $v_r = 100 \text{ km s}^{-1}$ . This list consisted of 2123 stars. However, there are radial velocities included in ARIHIP for some stars so in the second step we used these values and again adopted  $v_r = 100 \text{ km s}^{-1}$  for the rest of the stars. We found ARIHIP velocities for 824 stars and as a consequence 738 of them have been rejected because of the recalculated miss-distance greater than 5 pc. Only 86 were adopted as the Oort cloud perturbers (hereafter LP).

Next we searched other sources for the missing radial velocities. The most helpful were the ADS (<http://adswwww.harvard.edu>) and CDS (<http://cdsweb.u-strasbg.fr>) services as well as the Bibliographic Catalogue of Stellar Radial Velocities available on the Internet (<http://www.casleo.gov.ar/catalogo/catalogoin.htm>). The latter is the 2002 update of the previously published version (Malaroda et al. 2001). As a result we found additional radial velocity values for 199 stars, 181 of which were subsequently excluded from the list: after recalculations their miss-distance become greater than 5 pc. The remaining 18 stars were added to the list of stellar perturbers (LP).

Finally we obtained two lists: LP, with the confirmed stellar perturbers among the ARIHIP stars with miss-distance less than 5 pc and the LC list of potential perturbers which radial velocities are still unknown. A detailed description of our LC list and its “most wanted” subset are presented in Sect.4 while the influence of the stars from the LP list on the Oort cloud comets motion will be discussed in detail in the separate paper, in preparation.

## 3 Observing plans for slow movers

As the number of slow movers is quite large, reliable measurements of their radial velocities will deserve a significant amount of observing time. The accuracy needed to filter out most of the non-significant objects (with relatively low  $v_r$ ) is not particularly high and thus it does not put a special demand on the instrumentation to be used. When found, slow movers with a high radial velocity can be studied further with a better spectrograph, yielding absolute accuracy on the level of  $0.1 \text{ km s}^{-1}$ .

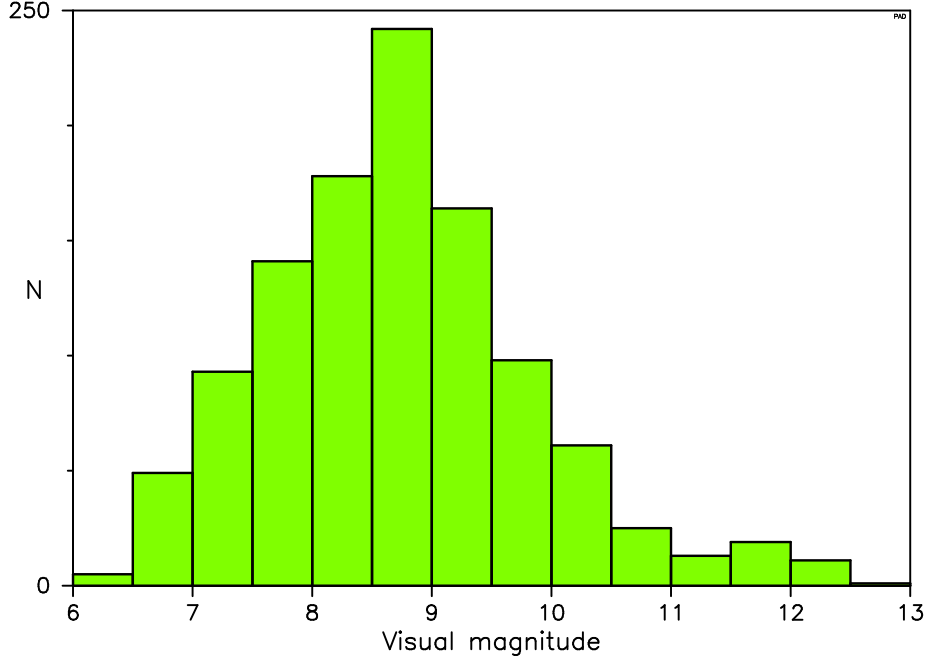


Figure 1: The distribution of the visual magnitude (copied from the ARIHIP catalogue) for the proposed 1100 target stars. The significant decrease of number of stars fainter than 9 mag is due to the Hipparcos catalogue limit.

There were several projects aiming at measurements of radial velocities of Hipparcos stars. Up till now they obtained radial velocities of several thousands objects (see for example Grenier et al. (1999); Nidever et al. (2002)), but their selection criteria were different from ours so it may take a lot of time before all slow movers are measured.

To speed up the process of building a database of slow movers radial velocities we would like to get observers interested in this group of star. To avoid unnecessary duplication of efforts we have set up the LC list of candidates for perturbers which is available on the web. The immediate aim of this would be to mark all stars that have already been measured even if the results are not publicly available yet. Later, as new radial velocities are being published, the list will be gradually changed into a database, which can easily be used for different research projects.

We are also planning our own observations with a newly build fiber-fed echelle spectrograph. While the main aim of this instrument will be radial velocity curves of binary stars, slow movers will also be measured during its free time.

Our new instrument allows us to measure radial velocities of late spectral type stars down to 8-9 mag, with 30-60 min exposures. The location of the telescope ( $\phi = 52^\circ$ ) sets additional constraints on the available targets. Going through our slow movers list and selecting stars with  $\delta > -8^\circ$  and spectral type later than F0 we obtain 18 stars with visual magnitude  $V < 7$  mag, 94 stars with  $7 < V < 8$  mag and 158 stars with  $8 < V < 9$  mag. We plan to observe them starting from the brightest end and moving on to the dimmer ones. As we progress, our list available at the web-page will be updated.

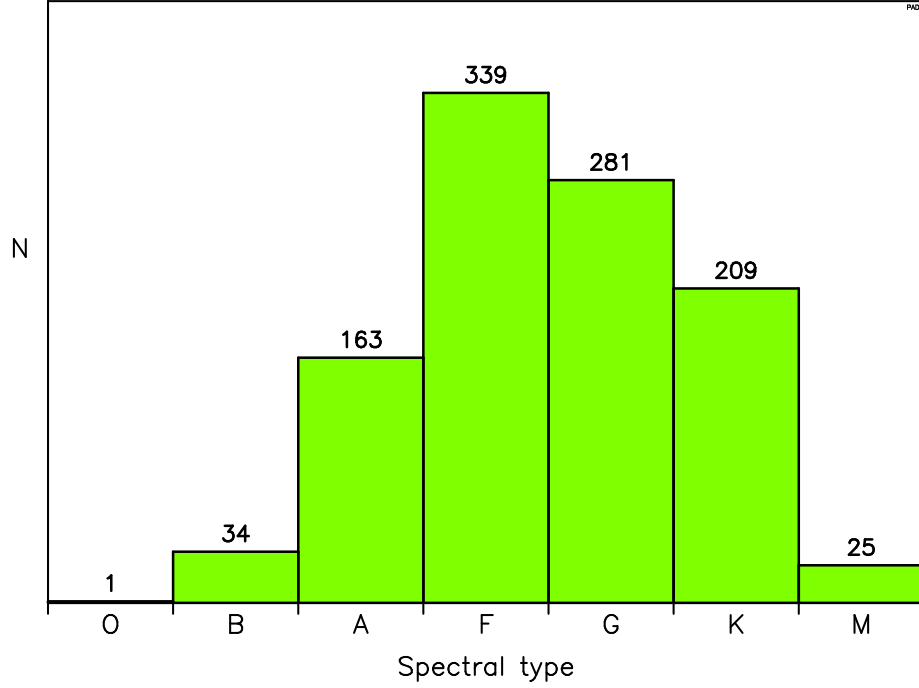


Figure 2: The distribution of the spectral type among the proposed targets. The number of stars in each type are shown on top of the corresponding bar. For 1100 stars present in our list we found 1052 spectral type descriptions, mainly in the Tycho-2 Spectral Type Catalogue (Wright et al. 2003). It should be noted that some of the spectral type assignments are very approximate.

Table 1: The “most wanted” list: 13 stars which have the Sun miss-distance less than 3 pc for the assumed radial velocity  $v_r = 20 \text{ km s}^{-1}$  only.

HIP	TYC	DD	V[mag]	$\alpha$	$\delta$	spectral type
6935	8036 01074 1	2.432	8.90	01 29 23.2	-47 56 23	F5 IV/V
15929	4715 00907 1	1.444	8.44	03 25 10.6	-06 44 08	F5 V
19527	0074 00247 1	1.605	8.50	04 11 00.5	+01 57 52	A9 V
24124	0111 00834 1	0.313	10.94	05 10 52.4	+06 16 28	
24600	4764 00700 1	1.495	9.58	05 16 36.5	-06 35 21	A2 IV/V
25469	0105 00438 1	2.643	8.51	05 26 48.1	+02 04 06	B8 V
29035	3386 00348 1	1.869	8.92	06 07 32.1	+51 57 32	G5
30108	3375 00998 1	0.823	8.03	06 20 09.5	+46 38 49	G5
30344	6510 01219 1	1.335	7.37	06 22 57.7	-24 33 22	K0/1 V
38205	9192 01237 1	2.844	8.91	07 49 39.1	-74 38 15	F6 V
56798	5513 00809 1	1.356	8.73	11 38 38.8	-11 14 20	G3 V
84263	9052 01617 1	1.778	8.50	17 13 30.2	-60 30 40	F7 V
112584	4477 01185 1	2.761	9.12	22 48 07.6	+69 04 30	G0

## 4 Proposed targets

As it was described in Sec.2 after using all radial velocity values available to us we shortened the LC list to 1100 stars. All of them have the Sun miss-distance less than 5 pc assuming  $v_r = 100 \text{ km s}^{-1}$ . In Figs. 1 and 2 we present distributions of the visual magnitude and spectral type among proposed targets. As it can be easily noted, these stars are relatively bright and the majority of them are of late spectral types. The proposed targets list (LC) is available on the web at the address: <http://www.astro.amu.edu.pl/Science/SlowMovers/>.

The main list is named *targets.lst*. The first column gives the Hipparcos number of the star (strictly ascending), next is the Tycho-2 corresponding number and the third column shows the calculated Sun miss-distance ( $DD$ ) in parsecs. The lower is the  $DD$  value the higher is our interest in this particular object, ie. the probability of confirmation that the star is actually the Oort cloud perturber.

For the user convenience in the next four columns we added the visual magnitude of the star, its position in the sky (J2000 Right Ascension and Declination) and its spectral type copied from the Tycho-2 Spectral Type Catalog (Wright et al. 2003), recently made available at CDS. >From our 1100 stars 96 are not included in this catalogue but with the help of SIMBAD database we decreased the number of missing spectra down to 48 stars.

The calculated Sun miss-distance of each star on the LC list is computed for the assumed  $v_r = 100 \text{ km s}^{-1}$ . To obtain the “most wanted” group of targets we repeated all the calculations, now assuming  $v_r = 20 \text{ km s}^{-1}$  and limiting the Sun miss-distance  $DD$  to be smaller than 3 pc. This gave us a list of 13 stars of particularly high probability of confirmation as an Oort cloud perturber. They are listed in Tab.1.

## 5 Conclusions

As it was mentioned above, the main purpose of this paper is to raise the interest in measuring radial velocities of the proposed 1100 low proper motion stars. Due to the current location of our instrument we cannot observe stars having declinations below  $-8^\circ$ . There are 572 such stars in our list. We are also restricted to the brighter end of the list but still the number of stars is quite large: it takes time to determine the absolute radial velocity of the star, especially when several subsequently obtained values are not consistent with each other.

So, here is the “call for cooperation”. We offer some kind of coordination by marking as “done” already measured stars or marking as “planned” other targets upon the information obtained from observers. First such marks were added to our list during the preparation of this manuscript. Following the private communications from Dave Latham we marked stars that have several unpublished radial velocity measurements made with CfA Digital Speedometers (238 such stars) and stars included in the CfA list of 10000 main-sequence stars closer than 100 pc and that have at least one new CfA radial velocity (unpublished) measurement (142 such stars).

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